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FURTHER MATERIAL OF CAMERONASPIS, WITH OTHER FORMS (HOMOPTERA: COCCOIDEA: DIASPIDIDAE)

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Abstract

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Two new species of *Cameronaspis*, *C. dilleniae* occurring on *Dillenia* sp. and *C. ilicis* on *Ilex revoluta*, are described from high altitudes on Mt. Kinabalu, Sabah (Borneo Is.), Malaysia, and *C. adinandrae* is recorded from Sabah and Nepal and from *Adinandra* sp., *Vernonia arborea*, and *Eurya acuminata*. The known species of *Cameronaspis* are revised, and their status as species is discussed. Two new genera are proposed, based on two new species: *Kuchingaspis hopeae* occurring on *Hopea* sp. at Kuching, Sarawak (Borneo Is.), and *Larutaspis lithocarpi* associated with *Lithocarpus wallichianus* on Bukit Larut, Malaya. *Pinnaspis megaloba* Takahashi, 1942, is transferred to *Larutaspis* on the basis of the original description. Another species was collected in association with *Kuchingaspis hopeae*, and is tentatively placed in *Chionandaspis*, but it is not formally named. All the genera treated in this paper belong to the subtribe Chionaspidina, and are similar in the median trullae prominent and set close, appressed together, or fused together and the second trullae reduced to very small pointed processes in the adult female. They distinctly differ in some other details, and may not be closely related to each other in spite of the similarity, which should involve convergence and/or parallelism.

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Introduction

The genus *Cameronaspis* was erected for three species collected on the Cameron Highlands, Malaya, Malaysia, one of them having been recorded also from Nepal. Another species, *Africaspis orchidarum*, which had been found on orchids exported from the Philippines (Ferris, 1955) and Singapore (Munting, 1967), was transferred to the genus on the basis of the original description. Thus the supposed occurrence of *Africaspis*, a predominantly African genus, in tropical Asia (and also in Australia) was seriously doubted if not completely negated. *Cameronaspis* and *Africaspis* proved to belong to different taxonomic groups especially on the basis of the second-instar male. The close resemblance between the *Cameronaspis* species and the type species of *Africaspis* in the adult female, therefore, was attributed to convergence (Takagi, Tho, and Khoo, 1988).

In describing *Africaspis orchidarum*, Ferris (1955) treated *Neopinnaspis* as a synonym of *Africaspis*. When McKenize (1949) erected *Neopinnaspis*, he supposed the genus to have some affinities with both *Pinnaspis* and *Lepidosaphes*. In a recent classification of the Diaspididae, these genera represent different higher taxa — tribes and subtribes — so that the cause of the taxonomic confusion about them is also attributable to convergence. (The view is adopted that the tribes Diaspidini and Lepidosaphidini are distinct taxa and the subtribes Chionaspidina and Fioriniina are good taxa under the Diaspidini. *Neopinnaspis* and *Lepidosaphes* belong to the Lepidosaphidini, *Cameronaspis* and *Pinnaspis* are assigned to the Chionaspidina, and *Africaspis* is referable to the Fioriniina.)

To take another example of confusion, *Phenacaspis* as composed by authors was an artefact and involved a number of species that are now divided into chionaspidines (leaf-associated forms of *Chionaspis*; non-typical forms of *Aulacaspis*) and fioriniines (fusiform forms of *Pseudaulacaspis*). Convergence and, needless to say, also parallelism should be universal especially in the external morphology of the adult female, because this stage persists in the life cycle and, therefore, is of central importance in adaptive evolution. When convergence and parallelism take place among genera belonging to the same subtribe, it would not be easy to decide whether a close similarity in adult female characters reflects a close phylogenetic relationship or involves convergence and/or parallelism.

In the present paper, further material of *Cameronaspis* from Sabah (Borneo Island) and Nepal is treated. Three species are recognized, and two of them are described as new species from high altitudes on Mt. Kinabalu, Sabah: *C. dilleniae* (sp. nov.), *C. ilicis* (sp. nov.), and *C. adinandrae*. In the course of the present study, some other forms belonging to the subtribe Chionaspidina have been examined. They are more or less similar to *Cameronaspis* in the median trullae prominent and set close, appressed together, or even fused together and the second trullae reduced into very small pointed processes in the adult female. Three species in three genera out of them are described in this paper, one of the species being not formally named but designated by a tag coined by combining abbreviations of the collection year, locality, and host plant: *Kuchingaspis hopeae* (gen. et sp. nov.), *Larutaspis lithocarpi* (gen. et sp. nov.), and *Chionandaspis* 91Kc-H. *Pinnaspis megaloba* Takahashi is transferred to *Larutaspis* on the basis of the description. These three genera distinctly differ in some other details from *Cameronaspis* and from each other, and all these genera may not be so closely related as suggested by

the similarity in the apical region of the pygidium. In most species of *Cameronaspis* and the species of *Kuchingaspis* and *Chionandaspis* the females burrow under the twig or leaf epidermis, and the similarity among the adult females of these genera probably has resulted from adaptation to burrowing.

The holotypes (adult females) of the new species formally named in this paper are deposited in Entomology Unit, Forest Plantation division, Forest Research Institute of Malaysia, Kepong, Kuala Lumpur, Malaysia.

Further material of Cameronaspis

Cameronaspis dilleniae, sp. nov.

Material examined. Collected in Taman Kinabalu [Kinabalu National Park], Gunong Kinabalu, Sabah (Borneo Is.), Malaysia, alt. 2750m, on *Dillenia* sp. (Dilleniaceae), 2 Oct. 1988 [88ML-29]. The female burrows in the lower surface of the leaves, leaving the first-instar exuvial cast exposed on the leaf surface; the affected spot of the leaf is slightly swollen on the lower surface and hardened on both upper and lower surfaces.

Many specimens of the adult female were mounted. A considerable proportion of them, however, are mummified apparently owing to parasitism by a hymenopterous insect, and in some of them the perivulvar disc pores are much fewer than in non-mummified specimens. The following description is based on 15 specimens, which show no evidence of reduction in the number of the perivulvar disc pores.

Adult female (Figs 1 and 2). Closely similar to the adult females of *Cameronaspis linderae* and *C. pustulifera* in the characters of the pygidial apex, especially in having well-developed second trullae and no marginal prominence between the median and second trullae, but distinguishable mainly in having submedian dorsal macroducts on the third abdominal segment; pygidium broader; wax-secreting organs generally tending to be more numerous. Anterior spiracles each with a compact group of 25–51 disc pores (which were not exactly counted in some specimens); posterior spiracles each with a group of 10–17 disc pores (mean 14.5). Perivulvar disc pores numerous, 26–37 (mean 30.9) in median group, 36–63 (52.9) in each anterolateral group, and 27–53 (40.3) in each posterolateral group. Dorsal macroducts forming distinct submedian and submarginal rows; submedian macroducts occurring on abd III–V, 1–4 (mean 2.6) on III, 2–7 (4.1) on IV, and 2–5 (3.3) on V; submarginal dorsal macroducts present or absent on abd II, always present on III–V, 0–4 (mean 2.5) on II, 4–9 (6.1) on III, 2–6 (4.1) on IV, and 2–5 (3.5) on V. Lateral macroducts abundant, 5–15 (mean 8.9) on metathorax, 13–24 (17.6) on abd I, 8–17 (11.3) on II, 4–10 (7.1) on III, and 2–6 (3.8) on IV. A few submedian dorsal microducts (at times replaced by small macroducts) occurring on abd II and also on I. Ventral microducts abundant on thorax, some of them replaced by minute gland spines. Abd I with 1–6 (mean 3.4) small gland spines on lateral lobe; gland spines occurring on II and III tending to be longer, situated near or on margin, 6–10 (7.2) on II and 2–10 (7.6) on III; 5–11 (7.6) long gland spines marginally on IV and 1–3 (2.5) on V; 2 marginal gland spines on VI, the posterior one of them much shorter than the anterior; 1 or 2 short gland spines on VII (laterally to second trulla); 1 small gland spines on VIII (between median and second trullae). No distinct submarginal dorsal bosses discernible.

Remarks. Male tests were found in the material, occurring on the lower surface of the leaves, and a few specimens of the second-instar male were mounted. However, some adult female specimens of a species of *Aulacaspis*, another genus of the subtribe

Chionaspidina, were also mounted from the material, and it has not been determined whether the second-instar male belongs to *Cameronaspis dilleniae* or the *Aulacaspis* species. This second-instar male (Fig. 3) does not agree with the second-instar males of four other *Cameronaspis* species (*C. linderae*, *C. pustulifera*, *C. adinandrae*, and *C. ilicis*, sp. nov.) mainly in having many small modified ducts scattered submarginally on the dorsal surface of the abdomen.

This species seems to be especially closely related to *C. pustulifera* on account of the reactions of their host plants. The burrowing female of *C. dilleniae* causes hardening, and that of *C. pustulifera* a pustulous growth, on the leaf epidermis at the feeding spot.

Cameronaspis ilicis, sp. nov.

Material examined. Collected in Taman Kinabalu [Kinabalu National Park], Gunong Kinabalu, Sabah (Borneo Is.), Malaysia, alt. 3300m and 3100m, on *Ilex revoluta* (Aquifoliaceae), 30 Sept. and 2 Oct. 1988 [88ML-18 and –23]. Females occurring mainly on the twigs and also on the leaves (at the base of the lower surface and at times of the upper surface) and petioles; males on the lower surface of the leaves. Females do not burrow, their tests being exposed, white, elongate, and convex dorsally, those on the leaves being broader; male nymphs settling themselves close together to make the shape of their individual tests obscure.

The adult female is described on the basis of 17 specimens from the twigs and 12 from the leaves. No difference has been observed between the twig and leaf forms.

Adult female (Figs 4 and 5). Very similar to the adult female of *Cameronaspis adinandrae* in having small second trullae and a small pore prominence between the median and second trullae, but distinguishable from that species in having much more macroducts. The pygidium appears somewhat broader than in that species. Anterior spiracles each with 13–38 (mean 20.2) disc pores; posterior spiracles each with 2–10 (5.3). Perivulvar disc pores: 16–30 (mean 21.9) in median group, 27–60 (42.8) in each anterolateral group, and 17–54 (34.4) in each posterolateral group (at times 1–4 disc pores present medially or submedially on segment just anterior to pygidium). Submedian dorsal macroducts always present on abd III–V, 2–5 (mean 3.1) on III, 1–6 (3.7) on IV, 2–5 (3.3) on V; 1 rarely present on VI. Submarginal dorsal macroducts on III–V, 6–16 (10.1) on III, 5–15 (9.2) on IV, 3–11 (6.8) on V. Lateral macroducts abundant on metathorax and abd I–III; absent or at times 1 macroduct present near margin on mesothorax; 7–16 (mean 11.0) on metathorax, 9–19 (14.7) on abd I, 7–15 (11.4) on II, 4–9 (5.9) on III; 1 or rarely 2 on IV, 1 or at times 2 (rarely absent) on V, these ducts being as large as the neighbouring marginal and submarginal macroducts. Ventral microducts abundant on thorax. Gland spines absent or 1–4 present on posterolateral corner of abd II, 2–6 (3.8) occurring on lateral lobe of III, 2–5 (3.7) on margin of IV; 1 or rarely 2 marginal gland spines on V and 1 on VI well developed; 1 on VII (laterally to second trulla); 1 small spine on VIII (laterally to median trulla).

Second-instar male (Fig. 6). Similar to the second-instar male of *Cameronaspis adinandrae* in having many large modified ducts, which are, however, more numerous than in that species. In some 15 specimens examined, the modified ducts counted 29–41 on each side of the abdomen.

Cameronaspis adinandrae

Takagi, Tho, and Khoo, 1988: 9 [Tanah Rata, Cameron Highlands, Malaya, alt. ca. 1300m,

on *Adinandra sarosanthera* (Theaceae); Nagarjun, near Kathmandu, Nepal, alt. 1470m, on *Eurya cerasifolia* (Theaceae), associated with a fungus].

Further material examined. Collected on the way from Sukhe Pokhri to Phidim, Mechi, Nepal, alt. 2120m, on *Eurya acuminata* (Theaceae), 11 Nov. 1983 [83NPL-160]; on Gunong Rinangsan, Banjaran Crocker, Sabah (Borneo Is.), Malaysia, alt. 1300–1400m, on *Adinandra* sp. (Theaceae), 8 Nov. 1988 [88ML-284]; at Kundasang, Gunong Kinabalu, Sabah, alt. 1550m, on *Vernonia arborea* (Asteraceae [Compositae]), 11 Nov. 1988 [88ML-335]. In 88ML-284 and –335, females were found mainly on the branches, often burrowing under a thin epidermal layer, and males on the lower surface of the leaves; in 83NPL-160 most female tests were hidden under mat-like mycelia of a fungus (probably belonging to *Septobasidium*) and no male tests were found. The present study is based on more than 30 specimens of the adult female (15 specimens mounted from material 83NPL-160 and another 15 specimens from 88ML-335; a few from 88ML-284) and 14 specimens of the second-instar male (7 from 88ML-284 and 7 from 88ML-335).

The adult females examined in the present study are closely similar to those in the type series from the Cameron Highlands in the numbers of the dorsal and lateral macroducts and are not much different from the latter in the numbers of the perivulvar disc pores. The anterior spiracular disc pores are widely variable in number, and are numerous in the specimens from 83NPL-160, but in the type series, too, these disc pores showed a wide range. The second-instar males possess 18–21 large modified ducts on each side of the body, thus nearly agreeing with those from the Cameron Highlands. The numbers of main wax-secreting organs in the adult females from 83NPL-160 and 88ML-335 are as follows:

Specimens from material 83NPL-160. Anterior spiracles each with 18–47 disc pores (not always exactly counted); posterior spiracles each with 4–8 (mean 6.7). Perivulvar disc pores 8–14 (mean 12.0) in median group, 19–30 (24.2) in each anterolateral group, and 11–24 (20.2) in each posterolateral group. Submedian dorsal macroducts few, absent or frequently 1 present on abd III, 1 or 2 (usually 1) on each of IV and V (rarely absent on V). Submarginal dorsal macroducts: 2–4 (usually 3) on abd III, 1–3 (usually 2) on IV, and 1 or 2 (usually 2) on V. Lateral macroducts: 2–7 (mean 4.5) on metathorax, 5–9 (6.6) on abd I, 3–7 (5.2) on II, 1–4 (2.8) on III, and 1 on IV. Gland spines: 1–3 minute gland spines on metathorax halfway between posterior spiracle and margin, 1–4 (rarely absent; mean 1.9) on II, 1–4 (3.4) on III, 2–4 (3.1) on IV, and 1 on each of V–VIII.

Specimens from material 88ML-335. Anterior spiracles each with 5–14 (mean 9.5) disc pores; posterior spiracles each with 1–4 (2.5). Perivulvar disc pores: 8–17 (mean 13.7) in median group, 15–34 (23.6) in each anterolateral group, and 12–27 (17.1) in each posterolateral group. Submedian dorsal macroducts: 1 present on abd III in 60% cases examined, 1 or 2 (mean 1.3) on IV, and absent or 1 or 2 (usually 1) present on V. Submarginal dorsal macroducts: 1–5 (mean 3.4) on abd III, 1–5 (2.2) on IV, and 1–3 (2.0) on V. Lateral macroducts: 2–8 (mean 4.6) on metathorax, 4–10 (6.5) on abd I, 3–8 (5.2) on II, 2–4 (3.1) on III, and 1 (rarely absent) on IV. Gland spines: 1 or 2 minute gland spines at times present on metathorax halfway between posterior spiracle and margin, 1 or 2 often occurring on abd II, 1–4 (usually 3) on III, 1–4 (mean 3.0) on IV, 1 or 2 (usually 1) on V, and 1 on each of VI–VIII.

Remarks. It seems that this species is primarily associated with plants of the family Theaceae. The form collected on *Vernonia arborea*, an arborous plant of the family Asteraceae, is not appreciably different in the external characters of both the adult female

and the second-instar male, and may rightly be referred to the species.

An overview on Cameronaspis

Cameronaspis

Takagi, Tho, and Khoo, 1988 [type species: *Cameronaspis linderae* Takagi, Tho, and Khoo, 1988].

The two new species described above require no substantial modification to the originally proposed concept of the genus, though in the adult female they have a somewhat broader pygidium and more dorsal macroducts than the other species.

The genus *Cameronaspis* comprises now six species, which are divisible into two groups based on the apical region of the pygidium in the adult female and may be separated in each group as follows:

Linderae group. Second trullae well represented, set close to median trullae, leaving little space between them; marginal macroduct of abd VII opening at base of second trulla, with the orifice surrounded by the sclerosis associated with the trulla. *C. linderae* [Cameron Highlands, 1600m, on *Lindera*]; *C. pustulifera* [Cameron Highlands, 1300–1600m, on '*Henslowia*' and *Euodia*]; *C. dilleniae* [Mt. Kinabalu, 2750m, on *Dillenia*].

Adult female with submedian dorsal macroducts on abd III–V. ..... *C. dilleniae*
Adult female with submedian macroducts on abd IV and V.
Female inducing a pustulous growth on host leaves; adult female usually without no gland spine (occasionally with 1) on lateral lobe of abd I; second-instar male with 1 submarginal modified duct in addition to 6 marginal ones on each side. ..... *C. pustulifera*
Female inducing no pustulous growth on host leaves; adult female with 1–5 gland spines on lateral lobe of abd I; second-instar male with 3 submarginal modified ducts in addition to 6 marginal ones on each side. ..... *C. linderae*

Adinandrae group. Second trullae less developed, separated from median trulla by a small membranous conical prominence, in which the marginal macroduct of the seventh abdominal segment opens. *C. adinandrae* [Cameron Highlands, 1300m, on *Adinandra*; Crocker Range, 1300–1400m, on *Adinandra*; Mt. Kinabalu, 1550m, on *Vernonia*; central and eastern Nepal, 1470–2120m, on *Eurya*]; *C. ilicis* [Mt. Kinabalu, 3100–3300m, on *Ilex*]; *C. orchidarum* [Philippines and Singapore, on commercial orchids].

Adult female with 'a very large cluster of extremely small pores' (Ferris, 1955) (which number over 200 in total in the figure accompanying the original description) on each anterior spiracle. ... . *C. orchidarum*
Adult female with less than 50 disc pores on each anterior spiracle.
Adult female with very few submedian dorsal macroducts (0 or 1 on abd III, 1 or 2, or rarely 0, on each of IV and V); second-instar male with 18–25 modified ducts on each side. ..... *C. adinandrae*
Adult female with more submedian dorsal macroducts (2–5 on abd III, 1–6 on IV, 2–5 on V); second-instar male with 29–41 modified macroducts on each side. ..... *C. ilicis*

The adult females of the species belonging to the same group are hardly distinguishable in the marginal characters of the pygidium. They are different in the

numbers of some wax-secreting organs, but the differences are mostly statistical. In general, diaspidid species have been distinguished by pygidial characters among others, and the numbers of wax-secreting organs are not always stable and sometimes widely variable in the same species.

The second-instar males of four species of *Cameronaspis* (*C. linderae*, *C. pustulifera*, *C. adinandrae*, and *C. ilicis*) are known, and the second-instar male mounted from material 88ML-29 possibly belongs to *C. dilleniae*. They are heteromorphic (for heteromorphism and homomorphism in the diaspidid second-instar male, see Takagi, 2003) and have a basic character pattern common to many heteromorphic chionaspidine second-instar males. They differ from each other especially in the number of the modified ducts and, thus, are useful in recognizing the species (despite the fact that many diaspidid species are hardly distinguishable in the second-instar male). *C. linderae* and *C. pustulifera* are very similar in the female, in which the latter noticeably differs from the former in inducing a pustulous growth on the leaves of its host plants, whereas these plants are not closely related to each other. The view that they are distinct species finds support in the second-instar male, in which they are clearly separable. However, in general, it is not self-evident that distinct forms in the second-instar male means distinct species: the possibility that they represent geographic, polymorphic, or ecophenotypic variation within the same species may not be excluded. Two distinct types of the second-instar male, both heteromorphic, were found in the fioriniine genus *Sinistraspis*, differing in the presence and absence of glanduliferous craters. Both these types were referred to *S. unilateralis*, because there were no distinct forms of the adult female corresponding to them. The examined specimens of the adult female were indeed widely variable in the size of the median trullae, but continuously, forming an indivisible series (Takagi, 2000).

It may be questioned, therefore, whether the species distinguished as such in each group of *Cameronaspis* are really good species. These species except *C. orchidarum*, of which the home is unknown, have been collected from montane localities 1300–3300m above the sea. *C. adinandrae* is now known from Borneo, Malaya, and the Himalayas, and the examined specimens should represent populations that are completely isolated from each other. It is associated with *Adinandra*, *Eurya*, and *Vernonia*, the last plant genus being not particularly related to the former two. And yet the allopatric forms and the 'allophytic' forms are not clearly distinguishable, closely agreeing especially in the numbers of the dorsal and lateral macroducts and prepygidial gland spines in the adult females and in the number of the modified ducts in the second-instar males. We may adopt this example as a test case and, then, we have no reason to suppose that the other species of *Cameronaspis* should necessarily be variable in the numbers of wax-secreting organs when occurring on discontinuous montane areas and on taxonomically remote plants. The two new species from Mt. Kinabalu, *C. dilleniae* and *C. ilicis*, differ from the other species especially in inhabiting much higher altitudes, and they are characterized in having more dorsal macroducts in the adult female. The second-instar male of *C. ilicis*, compared with that of *C. adinandrae*, is characteristic in having very numerous modified ducts. It is likely that *C. dilleniae* and *C. ilicis* are really good species adapted to high-altitude environments. However, *C. adinandrae*, too, occurs on Mt. Kinabalu and, therefore, the possibility that *C. ilicis* is an allotopic form of *C. adinandrae* should not be excluded. (This possibility will be enhanced if and when intermediate forms are discovered at intermediate altitudes.)

Kuchingaspis, gen. nov.

Type species: *Kuchingaspis hopeae*, sp. nov.

Referable to the subtribe Chionaspidina, tribe Diaspidini.

In the adult female this genus is somewhat similar to *Cameronaspis* and *Pinnaspis*, but differs in having no distinct zygotic sclerosis basally on the median trullae, which are completely fused together to form a robust lobe. No other scleroses present on trullae and pygidial margin. Anus situated towards base of pygidium, superimposed on median group of perivulvar disc pores.

Kuchingaspis hopeae, sp. nov.

Material examined. Collected at Kuching, Sarawak (Borneo Is.), Malaysia, on *Hopea* sp. (Dipterocarpaceae), 28 Sept. 1991 [91ML-1]. Females burrowing under a thin epidermal layer of the twig. Female test elongate, convex dorsally, probably white, appearing brownish owing to the colour of the covering host epidermis. Some 15 specimens of the adult female were examined, but not all of them were in good condition. Slender, tricarinate, and semierect male tests were found on the twigs. These male tests probably belong to this species, though a single adult female specimen of another species (*Chionandaspis* 91Kc-H) was also mounted from the material.

Adult female (Figs 7 and 8). Body elongate, about 4 times as long as wide at full growth, with free segments little lobed laterally; prepygidial derm remaining membranous; 3 submarginal dorsal bosses on each side of abdomen: 1 on each of abd I, III, and V; pygidium with apical sclerotized area on ventral surface well represented. Antennae on frontal margin, separated from each other by a space narrower than frame of mouth-parts, each with a short curved seta. Anterior spiracles each with 11–24 disc pores (not exactly counted in some specimens); posterior spiracles with no disc pores or at times with 1 or 2. Perivulvar disc pores in 5 groups, 8–18 (irregular in frequency distribution) in median group, 10–20 (mean 13.9, sample size 30) in each anterolateral group, and 5–15 (mean 11.2, sample size 30). Marginal macroducts (interpreted on the basis of some specimens in good condition): 1 on abd III, 2 on each of IV–VI, and 1 on VII, the last with orifice surrounded by a thick sclerosis and opening on base of second trulla. Dorsal macroducts, nearly of the same size as marginal macroducts, arranged in well-defined submedian and submarginal rows on abd III–V: 1–5 submedians (at times absent) and 1–4 submarginals on III, 1–4 submedians and 1 or 2 (usually 2) submarginals on IV, and 1–4 submedians and 1–3 submarginals on V. Lateral macroducts generally smaller, and small dorsal macroducts occurring across median and submedian areas on abd I–III, those on II and III tending to be confounded with lateral macroducts: 4–11 in posterolateral corner of mesothorax, about 19–36 in a broad lateral area on metathorax, about 25–45 and 29–38 on lateral lobes and across dorsal median and submedian areas on abd I and II respectively, 3–5 on lateral lobe and 0–8 across median and submedian areas on III, 1 or 2 on margin of IV as large as the marginal macroducts. Median trullae prominent, fused together to form a robust lobe, which is notched apically and twice on each side subapically; with no distinct zygotic sclerosis basally. Second trullae much smaller, represented by pointed processes, with no sclerosis basally. Tubercular gland spines occurring submarginally on abd I and II, 3–5 on I and 4–7 on II; 3–6 longer gland spines on lateral lobe of abd III and 2–5 on margin of IV; 1 marginal gland spine on each

of abd V–VIII, well developed on V and VI.

Chionandaspis 91Kc-H

Material examined. Collected at Kuching, Sarawak (Borneo Is.), Malaysia, on *Hopea* sp. (Dipterocarpaceae), 28 Sept. 1991 [91ML-1]. A single specimen of the adult female and two exuvial casts of the second instar female were mounted. This species was found in association with *Kuchingaspis hopeae*, gen. et sp. nov., of which the female specimens were mounted from under a thin epidermal layer of the twig. The presence of *Chionandaspis* 91Kc-H in the material was not noticed at starting preparation. The female specimen of this species may also have been cryptic on the twig.

The single female specimen available for the present study is affected by a fungus, a considerable part of the body being filled with hyphae. Main features are observable as described below and illustrated in Fig. 11, but the species is not formally named because of the poor condition of the specimen.

Adult female (Fig. 9). Body stout, with metathorax and abd I strongly and abd II moderately produced laterally; head with a widely flat frontal margin; pygidium broad and triangular. Antennae situated near frontal margin, separated from each other by a space narrower than frame of mouth-parts, each composed of stumpy tubercle and a curved seta. Anterior spiracles each with 7 (or about 7) disc pores; posterior spiracles with none. Perivulvar disc pores: 3 disc pores representing median group, arranged in a transverse row and widely separated from each other; lateral groups elongate, 11 or 12 disc pores in each anterolateral group, and 15 or 16 in each posterolateral group. Marginal macroducts: 1 on abd III, 2 on each of IV–VI each, and 1 on VII, the last being associated with a slender, pointed, membranous marginal prominence occurring between median and second trullae; mesal marginal macroduct occurring on VI longer than the other marginal macroducts. Submarginal macroducts on abd III–V, 3 on III, 2 on IV, and 1 on V; 2 submedian macroducts on abd IV. Lateral macroducts smaller, 2 on mesothorax, 3 on each of metathorax and abd I and II, and 2 on III. Short gland spines occurring on lateral lobes of prepygidial segments: 2 on each of meso- and metathorax, 3 on abd I, 4 on II, and 3 on III; marginal gland spines: 2 on abd IV, and 1 on each of succeeding segments, the posteriormost (on VIII) very small, lying on dorsal surface of median trulla. A sclerotized dorsal boss on base of lateral lobe of abd I; a smaller boss submargianally near supposed posterior border of abd V. Anus situated anteriorly to centre of pygidium. Median trullae well developed, set close together, round apically, with outer margin much longer and slanting, both inner and outer margins being minutely serrate; with an elongate elliptical median sclerosis arising at their inner bases; each trulla with a pair of linear scleroses arising from basal corners, the inner sclerosis curved to direct anteriorly, the outer straight, diagonal. Second trullae very small; inner lobule represented by a sclerotized conical process, with a somewhat clavate sclerosis basally, and the outer reduced to a slight prominence.

Remarks. The genus *Chionandaspis* was described on the basis of three species, two of them occurring in Sarawak and the other on Palawan Island (Takagi, 2003). In these species, the females burrow under the twig or leaf epidermis. They possess prominent median trullae and much reduced second trullae as in *Cameronaspis* and the other genera treated in this paper. They are especially characteristic in having remarkably developed, peculiarly shaped scleroses at the basal corners of the median trullae and elongate slender marginal and dorsal macroducts.

The present species is referred to *Chionandaspis* rather tentatively. It is very similar to the three species in the state of the median and second trullae. It agrees with them in having scleroses on the bases of the median and second trullae, but differs in the scleroses of the median trullae simply linear. The mesal marginal macroduct occurring on the sixth abdominal segment is somewhat elongate but not slender, and the other marginal and dorsal macroducts are usual in shape. Furthermore, the anus is situated closer to the base of the pygidium than in the three species.

The second-instar males of the type species and another species of *Chionandaspis* are characteristic in having a pair of broad projections at the apex of the pygidium. Further material of *C.* 91Kc-H including the second-instar male, therefore, is needed for proceeding with the generic position of the species.

Larutaspis, gen. nov.

Type species. *Larutaspis lithocarpi*, sp. nov.

Referable to the subtribe Chionaspidina, tribe Diaspidini.

In the adult female this genus is similar to *Cameronaspis* and *Pinnaspis*, but is distinguishable from the latter mainly in the median trullae with a pair of slender transverse scleroses arising at the outer basal corners and in the anus situated posteriorly to the centre of the pygidium. The median trullae are prominent, roundish on the margin, and elaborately striate, with a round zygotic sclerosis basally.

Larutaspis lithocarpi, sp. nov.

Material examined. Collected on Bukit Larut [Maxwell Hill], alt. 460m, Perak, Malaya, Malaysia, on *Lithocarpus wallichianus* (Fagaceae), 7 Oct. 1986 [86ML-119]. Females occurring on the upper surface of the leaves, mainly on veins and beside the midrib; female test slender, thin, and white, with the exuvial casts yellow. A few tricarinate male tests were also found on the upper surface of the leaves. The following description of the adult female is based on 15 specimens.

Adult female (Figs 10 and 11). Body elongate, attaining about 3 times as long as wide, flat on frontal margin, with free segments gently lobed; prepygidial derm remaining membranous; pygidium with apical sclerotized area on ventral surface produced anteriorly into a pair of slender prong-like extensions. Antennae near frontal margin, separated from each other by a space a little narrower than frame of mouth-parts, each with a short curved seta; a pair of derm pockets situated just posteriorly to antennae. Anterior spiracles each with 2–6 (mean 3.0) disc pores; posterior spiracles each usually with 1 disc pore (2 in one case, and none in another). Perivulvar disc pores in 5 groups, 3–7 (mean 5.2) in median group, 9–14 (11.5) in each anterolateral group, and 8–12 (9.3) in each posterolateral group. Marginal macroducts: 1 on abd III, 2 on each of IV–VI, and 1 on VII, the last associated with a slight membranous marginal prominence, and the two on VI opening in a somewhat sclerotized broad marginal prominence. Submedian and submarginal dorsal macroducts absent except for 1 submarginal duct occurring on abd IV. Dorsal microducts scattered on prepygidial abdomen in median and submedian areas except on basalmost segment. Lateral macroducts on abd I–III, 3 or 4 on I, 2–5 on II, and 1–3 on III. Median trullae well developed, appressed together except apically, gently rounded and minutely crenulated on outer margin, elaborately striate perpendicularly to outer margin, with a round zygotic sclerosis basally; a pair of short slender transverse scleroses arising from outer basal corners and a pair of short linear transverse scleroses

from inner basal corners. Second trullae with both lobules represented by very small conical membranous processes. Abd I and II each with 1–3 and III with 1 or 2 short gland spines on lateral lobe, IV with 1 or 2 longer gland spines on margin, V–VIII each with 1 marginal gland spine.

Larutaspis megaloba, comb. nov.

Pinnaspis megaloba Takahashi, 1942: 36 ['Indo-China: Haiphon, ... on an orchid'; 'Not a typical form of *Pinnaspis*'].

This species is transferred to *Larutaspis* on the basis of the original description. It agrees with *Larutaspis lithocarpi* in having a pair of slender transverse scleroses on the outer basal corners of the median trullae (the character clearly shown by the figure accompanying the description) and in the anus situated posteriorly to the centre of the pygidium ('near the apex' of the pygidium). So far as based on the description, it seems very similar to *L. lithocarpi* in other characters, too, except for the presence of eight groups of perivulvar disc pores, an unusual character in diaspidids.

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Fig. 1. *Cameronaspis dilleniae*, adult female. Scale bar: 100μm.

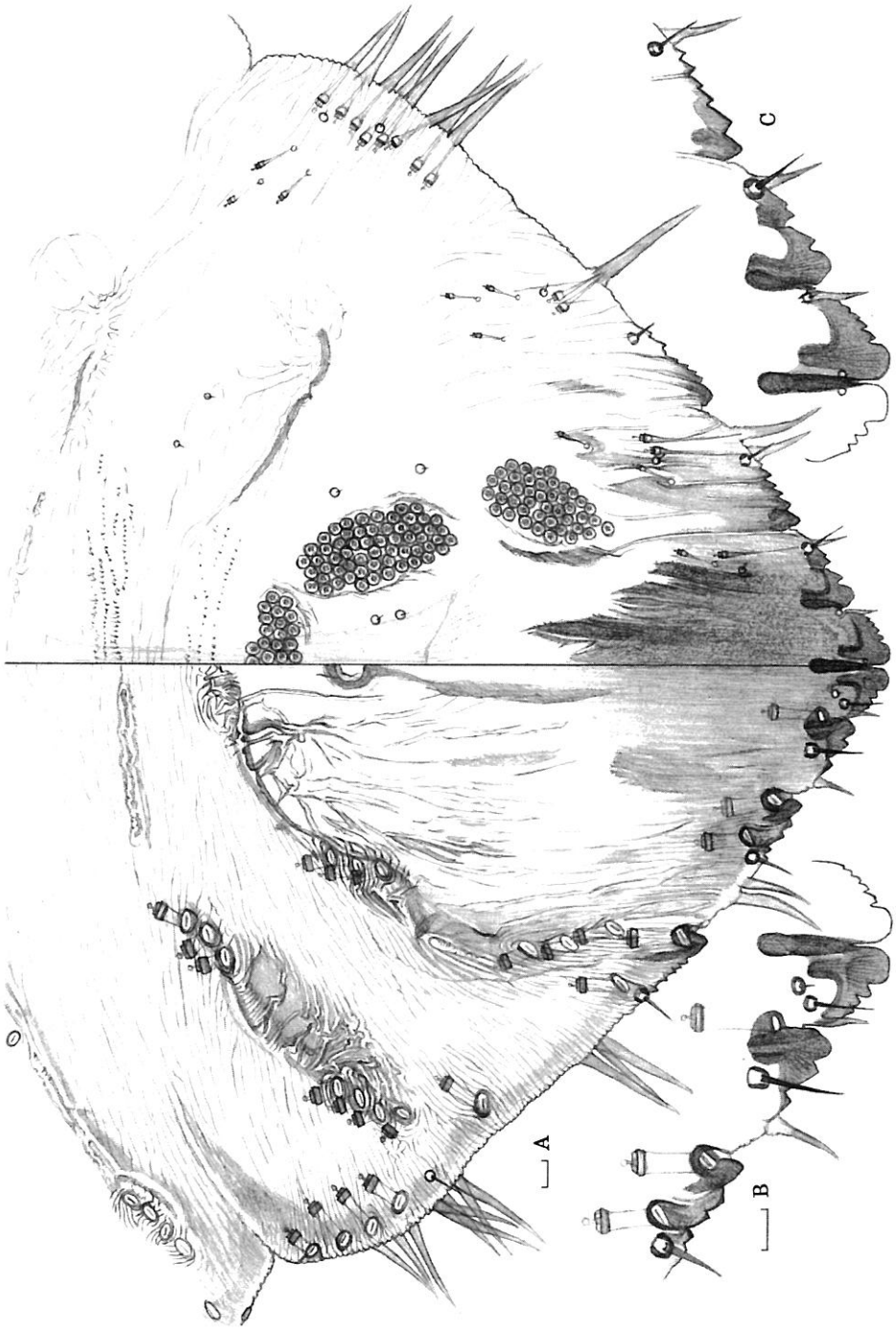

Fig. 2. *Cameronaspis dilleniae*, adult female: pygidium. B, apical margin of pygidium, dorsal view; C, apical margin of pygidium, ventral view. Scale bars: A and B, 10μm (C magnified at the same rate as B).

Fig. 3. Second-instar male mounted from material 88ML-29, possibly belonging to *Cameronaspis dilleniae*. B, modified ducts on fourth and fifth abdominal segments; C, apex of pygidium; D, large marginal modified ducts. Scale bars: A, 100μm; B, 10μm (C and D magnified at the same rate as B). The median ducts on the abdomen are depicted as occurring on the dorsal surface, though not all their orifices were clearly observable.

Fig. 4. *Cameronaspis ilicis*, adult female, on twig [88ML-18]. Scale bar: 100µm.

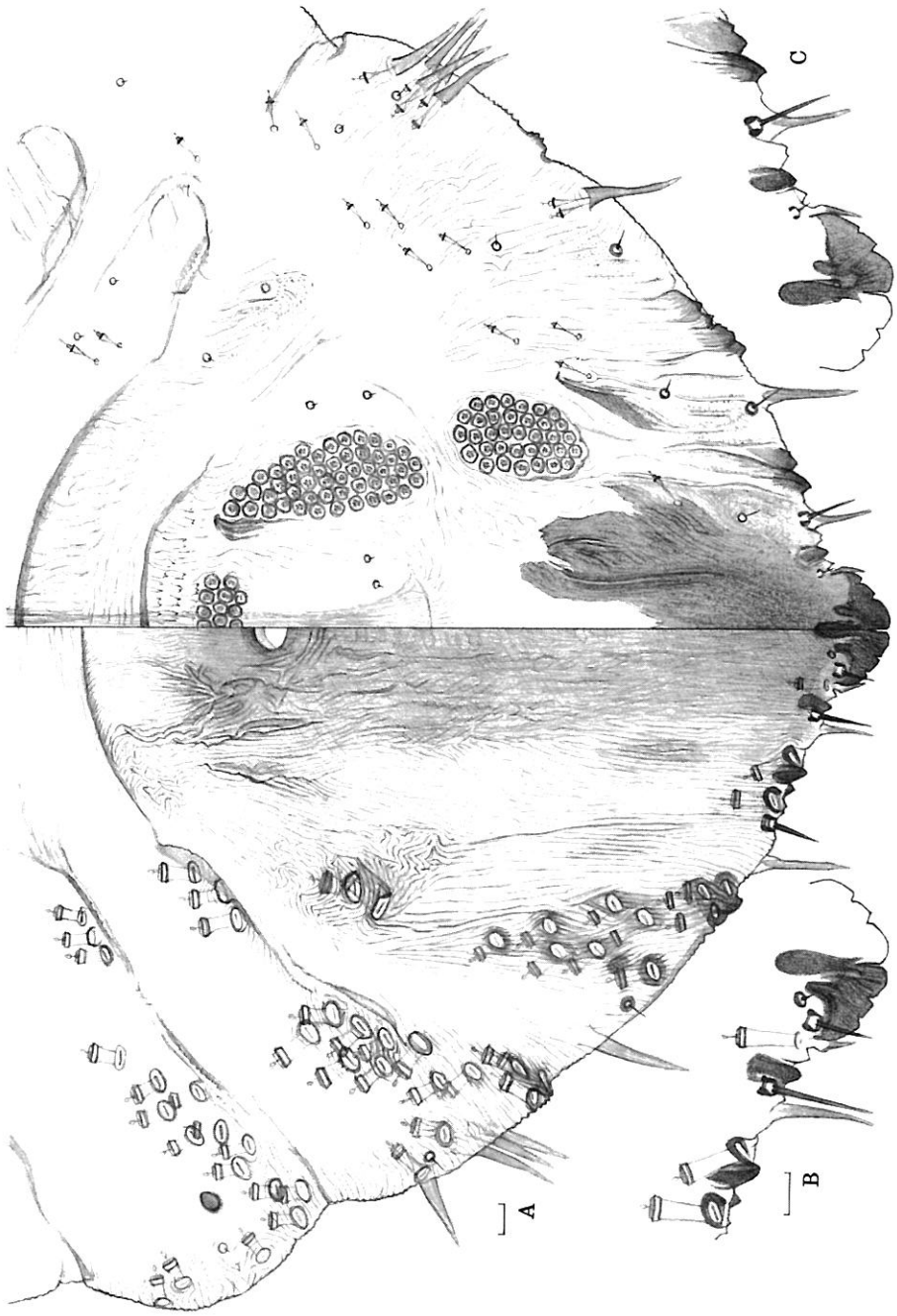

Fig. 5. *Cameronaspis ilicis*, adult female: pygidium, on twig [88ML-18]. B, apical margin of pygidium, dorsal view; C, apical margin of pygidium, ventral view. Scale bars: A and B, 10μm (C magnified at the same rate as B).

Fig. 6. *Cameronaspis ilicis*, second-instar male [88ML-18]. B, modified ducts; C, pygidial margin, ventral view. Scale bars: A, 100μm, B and C, 10μm.

Fig. 7. *Kuchingaspis hopeae*, adult female. B, median trullae, dorsal view; C, antenna; D, anterior spiracle. Scale bars: A, 100μm; B, 10μm (C and D magnified at the same rate as B).

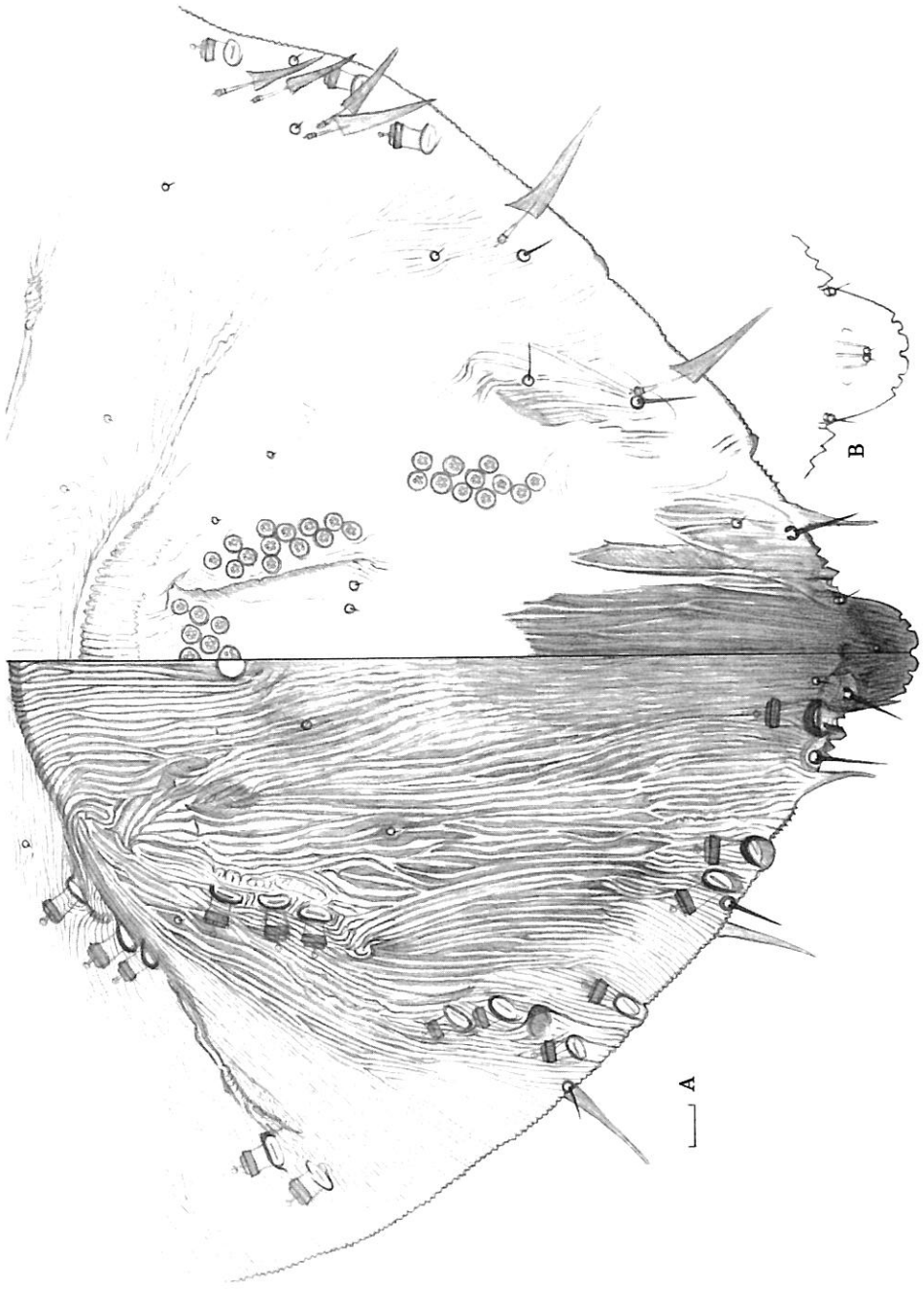

Fig. 8. *Kuchingaspis hopeae*, adult female: pygidium. B, median trullae, ventral view. Scale bar: A, 10μm (B magnified at the same rate as A).

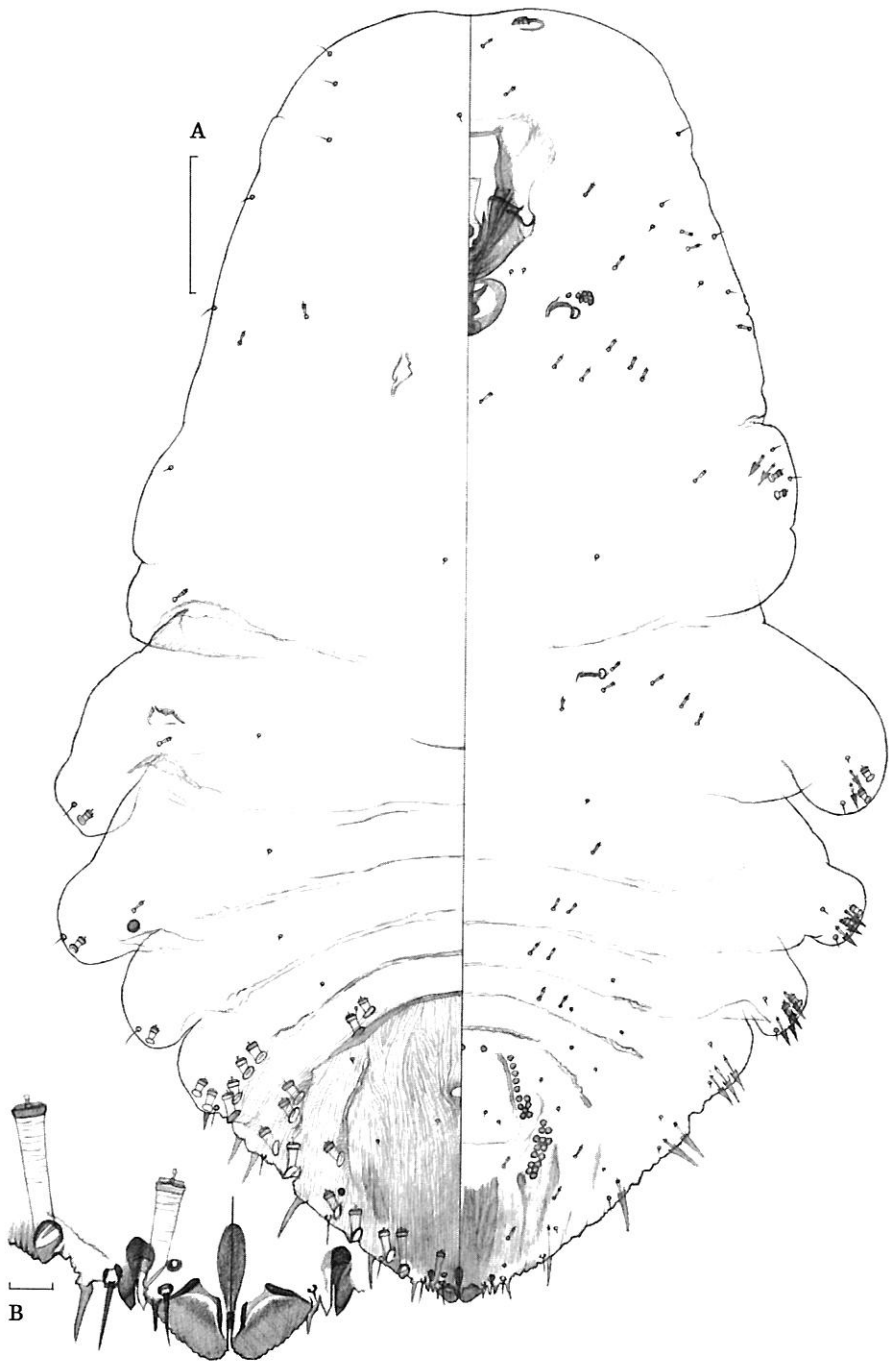

Fig. 9. *Chionandaspis* 91Kc-H, adult female. B, apical margin of pygidium, dorsal view. Scale bars: A, 100μm; B, 10μm.

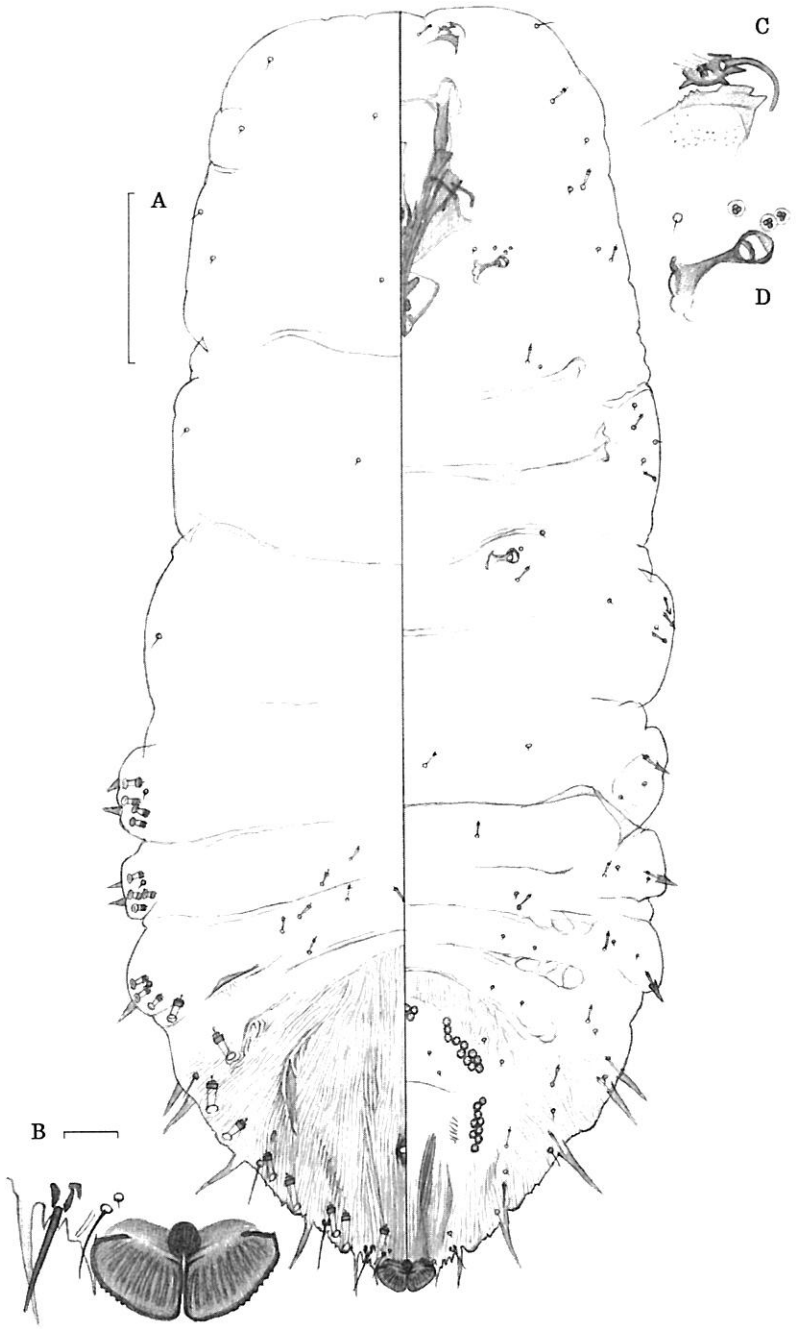

Fig. 10. *Larutaspis lithocarpi*, adult female. B, median and second trullae, dorsal view; C, antenna and derm pocket; D, anterior spiracle. Scale bars: A, 100μm, B, 10μm (C and D magnified at the same rate as B).

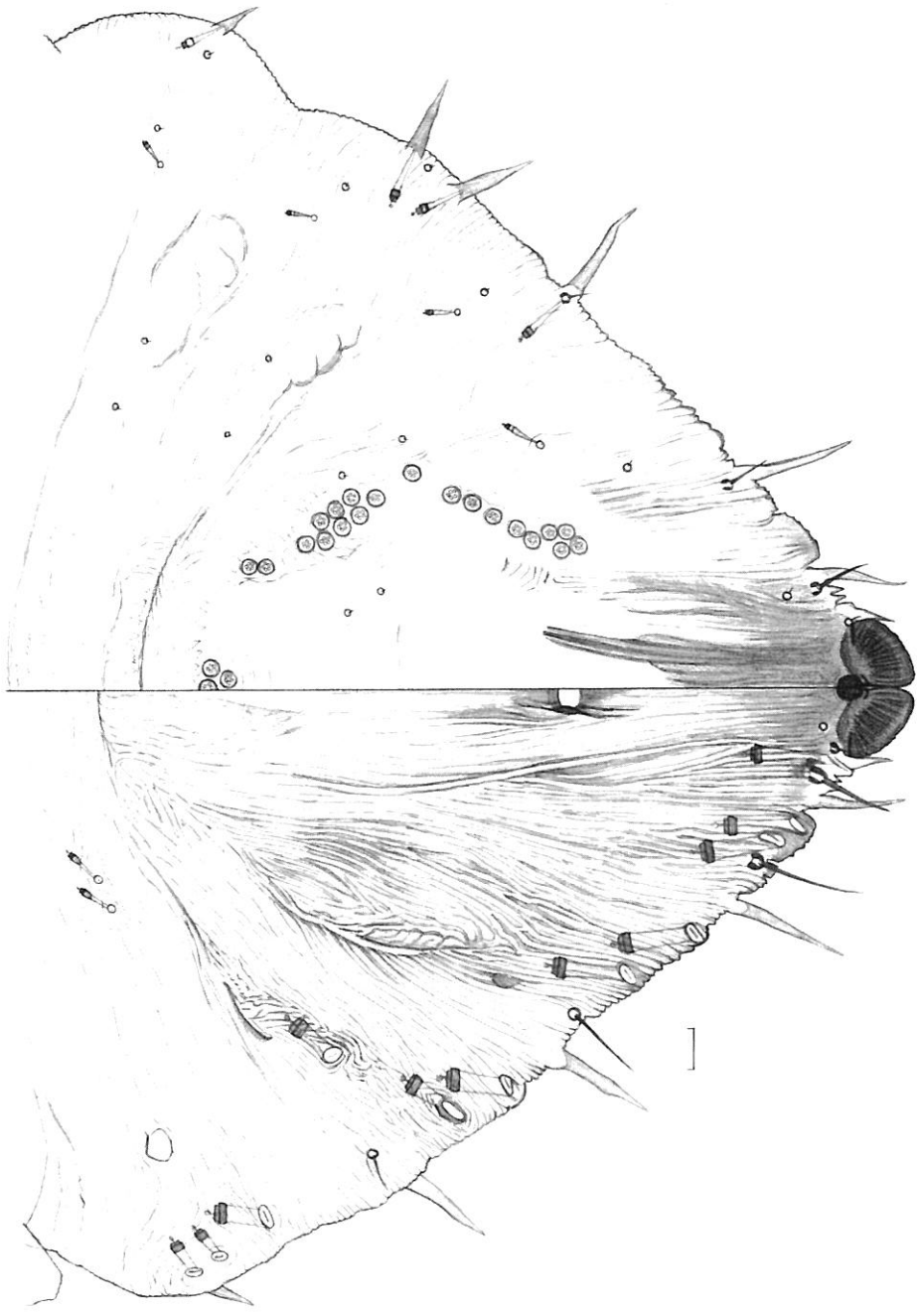

Fig. 11. *Larutaspis lithocarpi*, adult female: pygidium. Scale bar: 10μm.